Using spatial skills to interpret MAPS

Problem solving in realistic contexts

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use realistic contexts to engage upper primary students in substantive mathematical thinking.

One way of providing middle-school students with the opportunity to engage in realistic activities is to ensure that mathematical concepts and ideas can be taught and expressed in contexts closer to students' own experiences. Students are expected to learn serious, substantive mathematics in classrooms in which the emphasis is on thoughtful engagement and meaningful learning (National Council of Teachers of Mathematics, 2000). Lesh and Harel (2003) have indicated that the kind of problem-solving situations that should be emphasised in the classroom are simulations of real-life experiences where mathematical thinking is useful in the everyday lives of the student or their family and friends. Such problems are worthwhile since they tend to reflect the nature of "real" problems because they are complex, ill-structured, contain multiple perspectives and offer multiple pathways or solutions (Young, 1993).

Realistic contexts are best fostered when learning experiences include genuine resources (or artifacts) that provide opportunities for middle-school students to engage in mathematical ideas that are personal and meaningful (Clancy & Lowrie, 2002). These resources tend to have a strong spatial dimension in our highly visual world. We need only to consider the information contained in weather maps (see Figure 1) to appreciate the complex visual fields that are displayed around us and have become part of our lives. Students need experience in decoding and making sense of such information because of society's increasing use of

and reliance on multiple representations. Maps like those in Figure 1 are now dynamic, provide multiple sets of data, represent information in more than one way (e.g., use of colour and scale) and provide drop down menus that allow the user to consider "retrospective" and "prospective" forecasts.

In this investigation we consider the influence a genuine artifact has on students' spatial reasoning. We have found that middle-school students' are more likely to utilise a range of spatial skills to complete mathematics tasks when they are deeply engaged in an activity. We use artifacts that the students can readily relate to in everyday situations in order to enhance the authenticity of the classroom activity. Activities such as these allow students to embed themselves in the situation and thus help them make sense of mathematical ideas through spatial reasoning. Such skills and processes include building and manipulating mental representations of objects, perceiving an object from different perspectives and interpreting and describing physical environments. Spatial

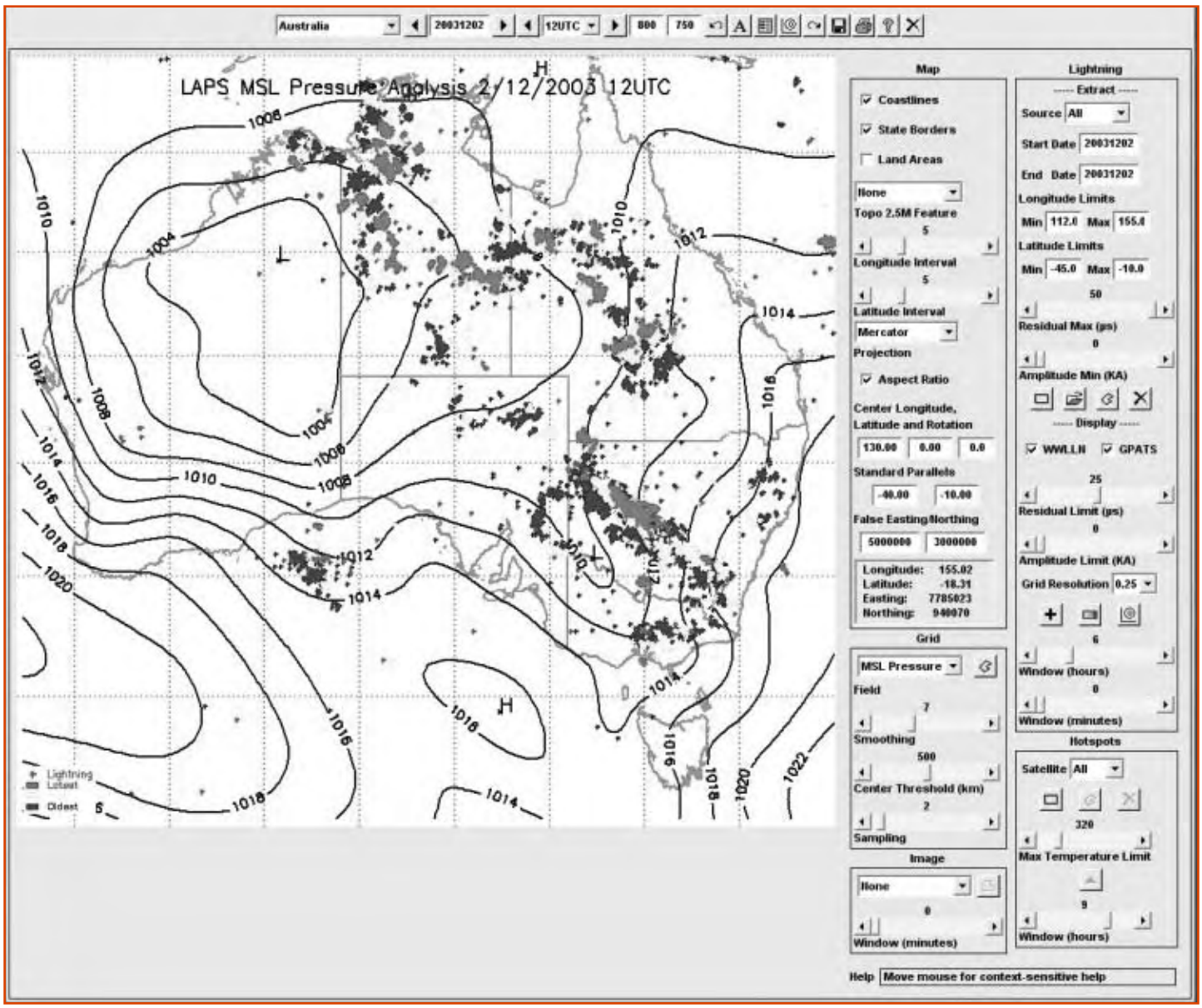

Figure 1. A dynamic weather map.

reasoning is especially useful in creating and reading maps, planning routes, designing floor plans, and creating art (National Council of Teachers of Mathematics [NCTM], 2000).

Using personalised experiences in sense making

The task was given to Grade 5 students (10 year-olds). We presented a scenario that was set within a context that the students could identify with and one in which they could use personal experiences in order to make mathematical connections. By using genuine artifacts we felt that the students would be even more likely to make connections to out-of-school experiences. The scenario was associated with the planning of a family outing to a theme park (amusement park with thrill rides and other attractions). Part of the scenario included:

Your challenge is to plan a day at the theme park with your family. The only information available for you is the pamphlet provided. This pamphlet shows the map of the entire theme park and the location of all the rides and attractions. To ensure that you make the best possible use of the day, you should consider which rides you would like to go on, and in which order. You should also indicate what and where you are going to eat during the day. In planning the day you should use the map as your main reference point. You will need to justify your solution.

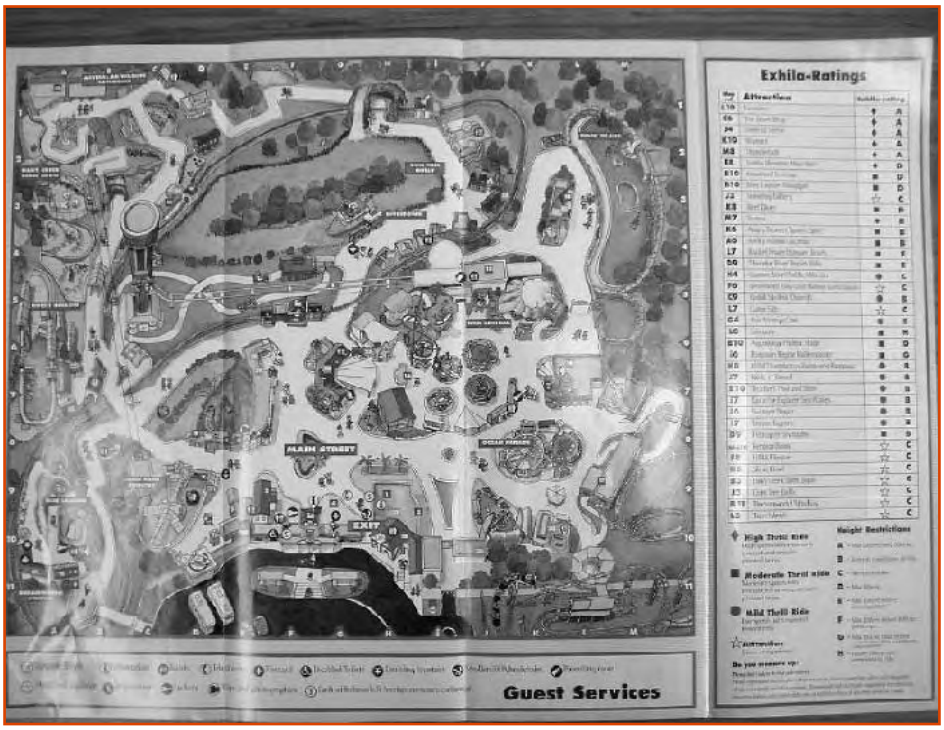

Figure 2. Dream World artifact.

The task required the students to plan the day by locating rides and attractions and subsequently indicating a sequence of events. In addition to the scenario, students were given a relevant pamphlet (including restaurant menus), and theme park map (see Figure 2 for an example). A range of visual processing skills was required to make sense of the map and the scenario. These realistic resources provided more information than was actually required for the students to complete the tasks but certainly added to its authenticity.

It was anticipated that a range of problem-solving skills would be accessed by the students as they made sense of the task. In particular, ideas about format and structure were considered as the students accessed information and made decisions about addressing the task. The collaborative environment that was established within the classroom context influenced the approaches the students undertook to gather information and represent the "problem scene". Despite the fact that the students lived more than 2000 kilometres from the park, almost one third of the students had visited this site — and almost all of the class had remembered visiting an amusement park like the one

described in the problem. In the first instance students tended to make lists or tables to collate information and organise data (see Figure 3). Many of the decisions made about directions to take, pathways to follow, or locations to visit were expressed (and often justified) in relation to personal experiences or existing knowledge of similar contexts. Although the actual task was relatively novel for most of the students, their everyday knowledge of the context allowed them to create solutions that were both personal and authentic. For example, students commented that the task may be difficult because other members of their family might want to do their own thing or they may want to split up and meet one another at a particular time for lunch.

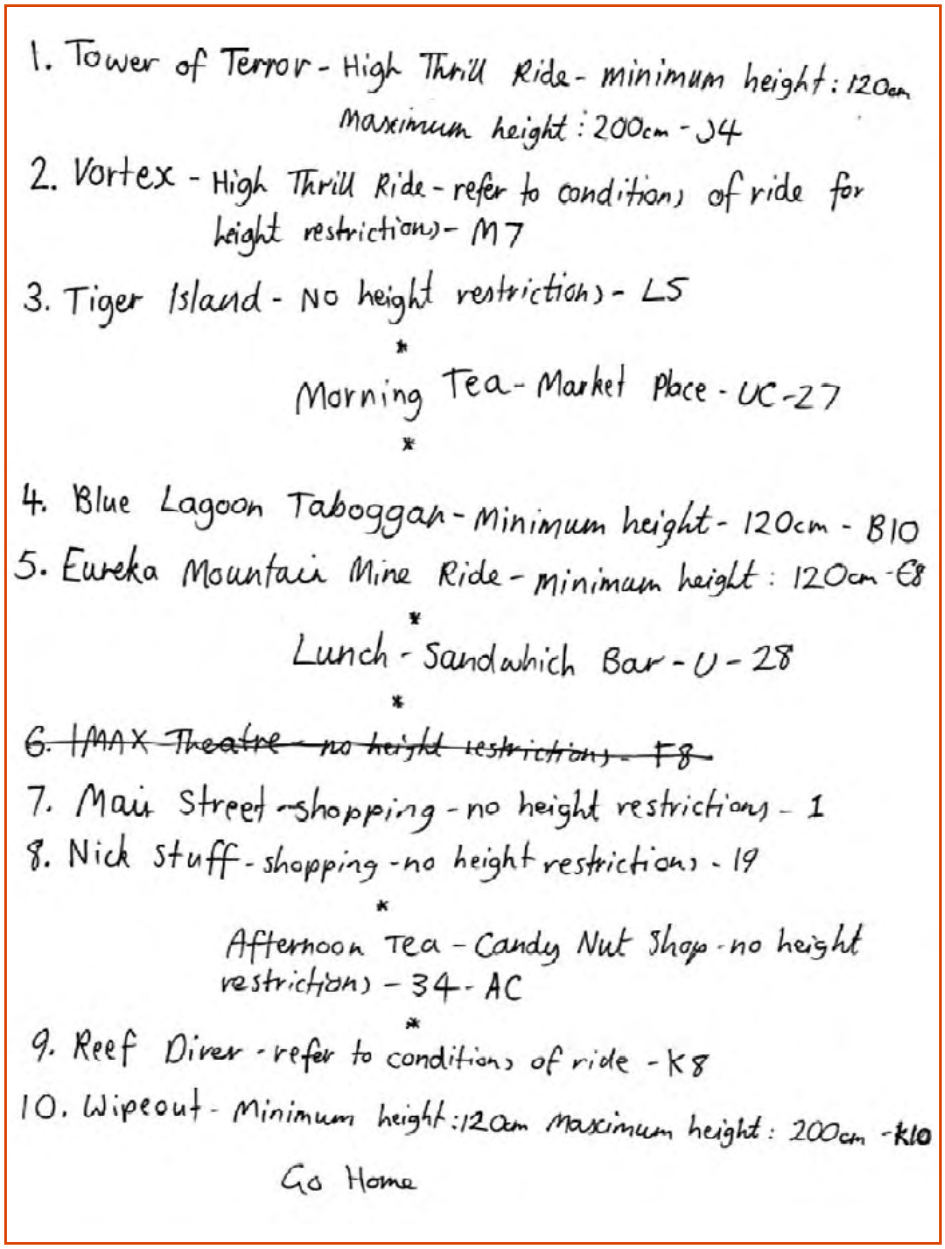
1. Tower of Terror - High Thrill Ride - minimum height: 120cm
Maximum height: 200cm - J4
2. Vortex - High Thrill Ride - refer to conditions of ride for height restrictions - M7
3. Tiger Island - No height restrictions - L5
*
Morning Tea - Market Place - UC-27
*
4. Blue Lagoon Taboggan - Minimum height - 120cm - B10
5. Eureka Mountain Mine Ride - minimum height: 120cm - E8
*
Lunch - Sandwhich Bar - U - 28
*
~~6. IMAX Theatre - no height restrictions - F8~~
7. Main Street - shopping - no height restrictions - 1
8. Nick Stuff - shopping - no height restrictions - 19
*
Afternoon Tea - Candy Nut Shop - no height restrictions - 34 - AC
*
9. Reef Diver - refer to conditions of ride - K8
10. Wipeout - Minimum height: 120cm Maximum height: 200cm - K10
Go Home

Figure 3. A child's timetable of events.

Some of the strategies used by the students involved working their way to a particular attraction and from there navigating their way back so that they were nearer to the exit by closing time. Others challenged themselves to go on every ride or to go on as many rides as possible. However, these strategies and approaches were the exceptions to the rule. The majority became fixated on the type of ride or attraction and fitting in as many as possible between the three designated breaks.

Using spatial skills to reflect upon solutions

Lowrie and Smith (2003, p. 2), in a special edition of the *APMC* which focused on spatial reasoning maintained that "visual and spatial skills and abilities are usually enhanced in situations where children are encouraged to visualise, manipulate and construct objects in real and simulated contexts". In this study, the students demonstrated the capacity to make sense of the maps and could accurately identify and apply coordinates to locate their chosen attractions despite the complexity of the map and the open-ended nature of the task. The intent of the task was to evoke visual reasoning through an activity that students could closely identify with, and thus, embrace

Lowrie and Smith's notion of visualising, constructing and constructing in personally identifiable contexts.

Interestingly, few students considered the travel path they had undertaken in order to complete the task. As a consequence, it was difficult for students to evaluate the efficiency of their solution. We then challenged them to visualise the pathway that they had undertaken through the timetabling of their day. This approach was successful for two reasons:

1. it allowed the students to represent their spatial knowledge in another form; and
2. provided a visual cue that allowed them to "see" their solution.

In other words, the students had moved from having to decode and process the information using imagery and other mental tools to representing these images in a concrete form (using diagrams and maps).

Most of the students were able to represent their solution from a bird's-eye perspective using coordinates and other mapping conventions (see Figure 4). Interestingly some of the students attempted to draw their map to scale instead of following the most direct route, "as the bird flies", by following the walking paths provided by the artifact (see Figure 5). In this way they were actually tracing their footsteps rather than aligning their pathways from point A to point B.

The children were thoroughly engaged in the task and described

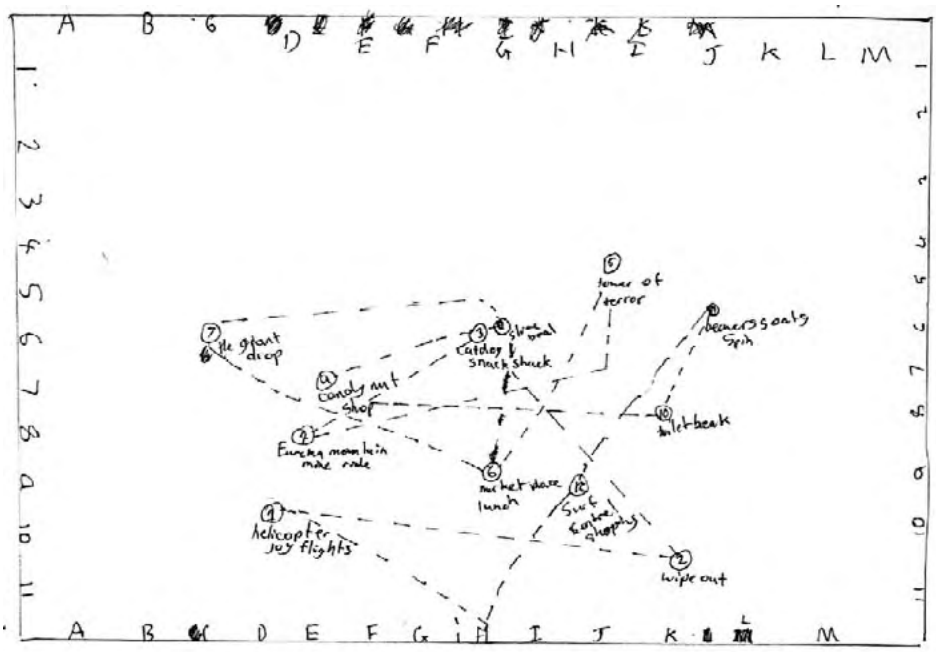

Figure 4. Following the most direct route.

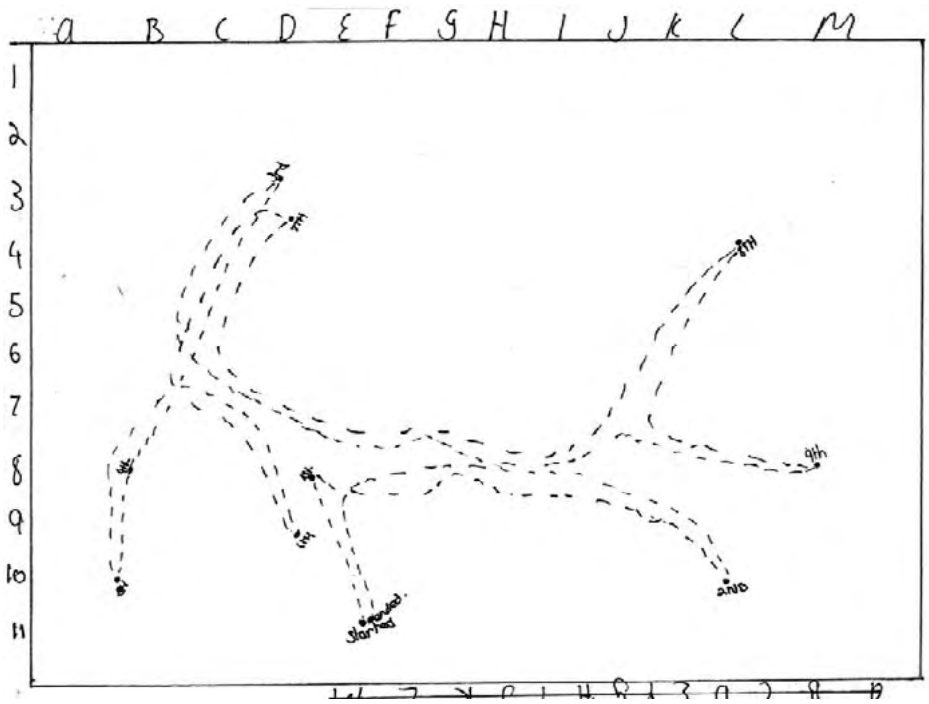

Figure 5. Following the walking paths provided by the artifact.

walking along paths, commenting that they felt like they were actually inside the theme park. By encouraging the students to use these visual techniques they were able to move both "inside" space (by getting a sense that they were actually moving around the park) and "outside" space (by considering the activity from a topographical perspective). The spatial reasoning required to represent their solutions offered opportunities for the students to interpret and describe 2D (and to some extent 3D) environments and promoted a range of problem solving tools.

Implications

We argue that this activity promoted middle-school students' spatial sense making by creating opportunities for the participants to:

- use a range of problem-solving tools to complete an activity that required the interpretation of information in various (visually rich) representations. In particular, visual and spatial approaches were utilised to great effect with the students manipulating mental representations, considering objects from different perspectives and locating objects in physical environments;
- visualise manipulate and construct spatial arrangements within scenarios that encourage the use of out-of-school knowledge and experiences.

The extension of the activity provided the students with the opportunity to evaluate their solution in a critical way and offered the opportunity for even more powerful problem solving to take place. Most of the spatial skills that were utilised in completing the scenario required visual imagery, the completion of tables or development of structured timelines. By representing their solution in another way the students were able to:

- consider information and solutions from a different perspective;
- provide a concrete representation that made it easier to see and interpret their solution; and
- reflect upon their solution and make judgments about its efficiency and practicality.

References

Clancy, S. & Lowrie, T. (2002). *Multimodal Meanings: The Pokemon Networks*. Refereed Proceedings of the Ninth International Literacy and Education Network Conference, Beijing, China [http://learningconference.publisher-site.com/].

Lesh, R. & Harel, G. (2003). Problem solving, modelling and local conceptual development. *Mathematical Thinking and Learning, 3* (2 & 3), 157–189.

Lowrie, T. & Smith, T. (2003). Editorial. *Australian Primary Mathematics Classroom, 8*(2), 2–3.

National Council of Teachers of Mathematics [NCTM]. (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

Young, M. F. (1993). Instructional design for situated learning. *Educational Technology Research and Development, 41*(1), 43–85.

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